PROC. R. SOC. VICT. vol. 95, no. 3, 139-145, September 1983

ECONOMIC ASPECTS OF THE CONTROL OF DRYLAND SALINITY

By R. G. Dumsday, D. A. Oram and S. E. Lumley

School of Agriculture, La Trobe University, Bundoora, Victoria 3083

Abstract: The paper reviews some of the obstacles to dryland salinity control and compares the advantages and disadvantages of various policy options. It is suggested that taxes per unit of salt emission or subsidies per unit of salinity reduction are theoretically preferred options against which more practical options may be compared. It appears that in more traditional areas of soil conservation, net returns to some components of publicly sponsored programs have been low or negative. It is argued, however, that returns to salinity control programs could be expected to be higher. A review of empirical economic studies of dryland salinity suggests that, in Victoria, there may be scope for alleviating the problem through relatively minor changes in existing farming systems. More drastic approaches such as reforestation may only be required in limited areas.

The problems of dryland salinity, irrigation salinity, and water quality are closely linked—both technically through the hydrologic cycle, and in economic terms through the relationships between resource use and production of agricultural commodities. There are also linkages between dryland salinity, soil erosion and water quality. For these reasons we shall at times group soil problems under the general heading of "soil degradation". The physical and biological processes involved in the particular case of dryland salinity are described by Peck (1978), and Jenkin & Morris (1983).

The damage caused by salinity is sometimes measured in terms of area of land affected, value of lost agricultural production, and costs imposed through decreased water quality. The estimates of damage in Table 1 have been adapted from Mitchell *et al.* (1978), and Cary *et al.* (1983) and employ 1980/81 prices.

Table 1 indicates that, in terms of the area of land affected and economic losses through reduced agricultural production, the impact of dryland salinity in Victoria is roughly equal to that of irrigation salinity. Both forms of salinity contribute to decreased water quality which is estimated to cost $7.3 million per annum.

Estimates of economic losses due to salinity are useful in drawing attention to the magnitude of the problem. However, such calculations do not indicate what action should be taken in response to the problem. The costs of controlling salinity may be greater than the anticipated benefits.

The benefits of salinity control may include:

- increased income to some farmers
- decreased expenses to rural, urban and industrial water users
- increased water-based production and recreation, particularly fishing
- an environment more favourable to flora and fauna
- increased forest-based production and recreation
- enhanced aesthetic appearance of landscapes.

The costs of salinity control may include:

- reforestation costs
- costs to farmers of landuse changes
- increased administration costs to public institutions.

The only Australian study that attempts to evaluate all the benefits and costs of dryland salinity control is that by Bennett & Thomas (1982).

We review some of the possible obstacles to the control of dryland salinity and compare the advantages and disadvantages of various policy options. Some empirical economic studies are briefly reviewed, together with the results of analyses conducted by the authors.

REASONS FOR GOVERNMENT INTERVENTION IN SALINITY CONTROL

Almost all production processes managed by man have the potential to cause damage to the environment. Fortunately, it is often in the manager's self-interest to ensure that the damage is avoided by adoption of appropriate practices. However, in the case of salinity—and of other forms of soil degradation and air, land and water pollution—there are several reasons why the firm or manager may not adopt systems and practices which avoid damage to the environment. These reasons have been described previously (Dumsday 1983) and may be summarised as: a, lack of knowledge concerning complex environmental relationships; b, uncertainty concerning the extent to which environmental degradation is irreversible; c, lack of concern for the off-site effects of landuse, such as salting of other land and salinisation of streams; and d, possible divergence between individual and community views of the importance of future costs and benefits. All these factors point to the desirability of public institutions taking an interest in assisting, or requiring, private landholders to control soil degradation.

The next section takes a closer look at the ways in which governments have, or could, intervene to ensure rational use of soil and water resources.

COMPARISON OF POLICY OPTIONS FOR CONTROLLING SOIL DEGRADATION

It may be useful to divide possible policies into two

TABLE 1
ESTIMATES OF ECONOMIC LOSSES DUE TO SALINITY

(A) *Loss of Production* (Vic.)	
Dryland Salinity	
Cropping Land	27 000 ha affected
Grazing Land	58 000 ha affected
Lost Production (net)	\$5.5 m/annum
Irrigation Salinity	
Kerang Region	75 000 ha affected
Shepparton Region	2 000 ha affected
Lost Production (net)	\$6.0 m/annum
(B) *Downstream Effects—Water Quality*	
Agricultural (Vic. & S.A. irrigation)	\$2.0 m/annum
Household (S.A.)	\$5.0 m/annum
Industrial (S.A.)	\$0.3 m/annum
Grand Total	\$18.8 m/annum

(Adapted from Mitchell *et al.* 1978; Cary *et al.* 1983)

groups—those that are aimed at overcoming "imperfections" in terms of producer knowledge and capital markets; and those that are concerned with divergences between private and socially optimal use of soil and water resources.

IMPROVING THE AVAILABILITY OF INFORMATION

The first group of policies largely concerns investment in research, education and extension programs aimed at improving the individual farmer's understanding of the impact that soil degradation has on his business. Such programs can probably be easily justified in economic terms, particularly under the conditions of widespread soil degradation that applied in Australia and the U.S.A. in the 1930s and the 1940s and that seem to be re-emerging in the 1970s and 1980s. Even under such conditions it would not generally pay an individual farmer to conduct his own research into degradation problems but, up to a given level of investment, society should benefit by sponsoring research programs for farmers as a group.

Farmers will normally adopt new practices emerging from the above programs if they can be persuaded that their net incomes will consequently increase. However, there may be situations where, for example, the farmer cannot obtain the necessary credit, even at competitive rates of interest. Governments may intervene in such situations to ensure that credit is made available, at competitive rates. The government's role here may consist merely of helping to persuade lenders that the expected net benefits of the investment will enable the borrower to repay the loan.

This group of policies can be aligned with similar policies in other areas of agricultural production. By increasing the rate of expansion and adoption of new technology both farmers and consumers are normally made better off. Generally speaking, the better the income-increasing ability of the new technology, the faster it will be adopted.

The policies to be discussed in the next section may sometimes be used as catalysts to the adoption of new technology. However, we believe that the existence of such policies should more commonly be seen as an admission that well-informed farmers have not found it profitable to adopt a given set of soil conservation practices deemed desirable by public agencies. Also, there is evidence that while some countries have met with considerable success in the "information" area, the performance of policies aimed at closing the gap between private and public "optima", has been disappointing, despite the expenditure of large quantities of funds (Comptroller General of the U.S. 1977, Williams 1979).

POLICIES FOR CLOSING THE GAP BETWEEN PRIVATE AND PUBLIC OPTIMAL USE OF SOIL AND WATER RESOURCES

In the following discussion policy options are grouped under three headings—taxes and subsidies on soil degradation; taxes and subsidies on inputs and outputs; and direct controls.

Per unit taxes and subsidies on soil degradation

Economists generally regard direct, per unit taxes on emissions of pollutants as the most efficient means of controlling pollution or soil degradation. See, for example, Amihud (1976), Anderson *et al.* (1978), Moffitt *et al.* (1978), and Seneca & Taussig (1979). Such direct taxes are generally advocated as being consistent with the "polluter pays principle". Critics of this proposal are quick to point out the serious legal, political and technical measurement obstacles to its introduction. To date these obstacles have prevented adoption of the idea in any part of the world to the authors' knowledge.

In the case of salinity problems, taxes could be imposed on salt emissions or "deep percolation" (recharge) of water from dryland agriculture. These procedures would not necessarily entail the difficult or impossible task of directly monitoring and measuring the pollutants at all times, in all locations. A more feasible alternative is to identify relationships between farming systems and salinity for various locations to facilitate indirect monitoring of pollution. Work by Bennett & Thomas (1982), and the authors, amongst others, is developing the necessary relationships. A theoretical treatment of production functions for nonpoint pollution is provided by Griffin & Bromley (1982). They emphasise that such functions would allow "economically efficient policies to be based upon those factors which determine pollution rather than the pollutant itself".

It is possible that technological developments in soil degradation measurement and modelling, and a continued poor performance of alternative policy instruments will lead eventually to the introduction of soil degradation taxes in some form or other. In the meantime they provide a useful basis for comparison with other policy instruments.

In theory, subsidies per unit reduction in soil degradation have the same effect as taxes per unit of remaining soil degradation, in terms of closing the gap between social and private optimal rates of soil utilisation. However, while taxes initially transfer income

from farmers to the community, subsidies do the opposite. In addition, subsidies may have two undesirable effects. First, they may not provide clear incentives for the development of least-cost systems of soil conservation. Secondly, they may actually encourage producers to expand cropping on to even more susceptible land in order to capture more subsidy (Baumol & Oates 1975).

Taxes and subsidies on inputs and outputs

Subsidies for soil conservation works and land management practices have probably been the most common form of public intervention up until now. Low interest loans and income taxation concessions for soil conservation works also come under the heading of subsidies on inputs.

The application of taxes or subsidies to inputs or outputs has at least three possible disadvantages. First, soil degradation is normally the result of interacting management factors and there is seldom good correlation between any one factor and the degree of soil degradation. Under such circumstances it is difficult to calculate the least-cost tax or subsidy package. Secondly, as in the case of direct subsidies per unit reduction in soil degradation, there is a danger of input subsidies leading to increased degradation as farmers find it profitable to cultivate more susceptible land. Thirdly, it may be quite difficult, in the case of input subsidies, to provide a continuing incentive for reducing the costs of soil conservation by the application of new technology.

The application of input taxes does not suffer the last two disadvantages. However, it is difficult to imagine an efficient input package for dryland salinity other than perhaps imposing additional taxes (or withdrawing current subsidies) on tractor fuels which, in some regions, would swing cost advantages away from fallowing in favour of reduced tillage systems. Taxes on conventional cultivation equipment or subsidies on minimum tillage equipment would be an alternative but the effects would take place gradually as farmers replaced their machinery. Increases in wage rates and oil prices relative to the prices of other factors of production like pesticides may have already provided incentives for producers to move towards minimum tillage systems. By maintaining plant cover for longer periods compared with traditional practices, such systems offer reduced soil erosion and reduced deep percolation of rainfall to groundwater. Crosson (1981) reviews a number of technical and economic issues relevant to comparisons between conventional and minimum tillage systems.

Taxes and subsidies on outputs have not been implemented specifically to meet soil conservation objectives. It would be possible to tax crop products (Seitz 1981) or subsidise pasture products but, again, these would be rather blunt instruments for controlling soil degradation. Schultz (1982) has pointed out that taxes on crops would penalise all crop producers regardless of whether or not their farms were contributing to soil degradation and water quality problems. However, it would be useful to remind policy makers from time to time of the implications for soil degradation on some farms of, for example, providing export incentives for crop production.

Direct controls

Direct controls include regulation; zoning; or prohibition of various forms of land use; or resumption of land in order to meet specified levels of soil conservation or salinity management.

Direct controls normally have several disadvantages. First, they tend to require a great deal of information on relationships between management practices and soil degradation if the controls are to operate efficiently. Second, they are often inflexible in the face of changes brought about by new technology. Third, the standards are usually arbitrary in economic terms, no attempt being made to compare the benefits and costs of more stringent standards with those for less stringent standards. Fourth, direct controls often do not allow the individual farmer enough discretion in choosing combinations of management practices and land uses to meet soil conservation objectives.

In practice, most governments have used a combination of measures from the two latter options to combat soil degradation. However, it is clear from Australian and U.S.A. experience that only partial success has been achieved (Comptroller General of the U.S. 1977, Department of Environment, Housing and Community Development 1978). Producers have tended, for example, not to maintain terrace systems or contouring practices and have even been permitted at times to use conservation funds for production activities which lead to overall increases in soil degradation.

RESULTS FROM EMPIRICAL ECONOMIC STUDIES

To economists, the degree of control over soil degradation to be desired depends on comparisons of benefits and costs, whether from an individual or community point of view. Some of the difficulties in performing these comparisons have been noted previously (Dumsday 1983). The diffuse, non-point nature of soil degradation processes and their effects in terms of water pollution and agricultural productivity further adds to the difficulties for benefit-cost analysis.

Despite the above difficulties, a large number of economic evaluations have been completed in the U.S.A. and, to a lesser extent, in Australia (Dumsday 1983). Broadly speaking, these studies show low or negative social returns to public programs aimed at reducing soil degradation rates below those incurred by profit-maximising individuals. However, they also show that, while some individuals may suffer significant income losses as a result of programs for soil conservation, the net social costs of significantly reducing soil degradation are likely to be low for efficiently run programs. Given the uncertainties discussed earlier "society" may be prepared to accept low or even slightly negative returns for such programs.

The studies referred to above mostly concerned themselves with more "traditional forms of soil de-

gradation such as sheet erosion in cropping areas. There are few comprehensive benefit-cost analyses of dryland salinity control programs, either in Australia or overseas. In our view the social returns from salinity control (over and above those concerned with the informational aspects discussed previously) may be higher than those for traditional forms of degradation because of the relatively greater importance of off-site versus on-site effects. The on-site effects of sheet erosion, for example, are often large and tangible in relation to the total social consequences of such erosion, so it is often in the individual's interests to do something about the problem. In contrast, the on-side effects of salinity processes initiated by a given form of land use may be small in relation to their off-site effects on streams or on land owned by other individuals.

As mentioned in the introduction, the only Australian study (and probably the only study in the world) that attempts a comprehensive evaluation of the benefits and costs of dryland salinity control is that reported by Bennett & Thomas (1982). This study took a multi-disciplinary approach to the evaluation of proposals for salinity control in wheat-growing areas in the Murray catchment of Western Australia. Table 2 summarises some of the results of the study and demonstrates that the evaluation was quite broad—capturing the benefits and costs of agricultural production, agroforestry, forestry, mining, recreation, and water storage.

On a catchment basis the results suggest that, compared with current landuse, economic returns could increase and stream salinity levels decrease, by increasing the area devoted to national parks, mining, and agroforestry, while reducing the area devoted to hardwood forest, and traditional agriculture. A study employing similar methodology to that of Bennett and Thomas is being conducted in Victoria by the authors.

A study reported by Greig & Devonshire (1981) was based on a cross-sectional regression analysis of 56 Victorian catchments. They found that levels of stream salinity across all catchments were satisfactorily explained by a function of the form:

$$S = f(T, R, P)$$

where S = mean stream salinity (mg/L, total dissolved salts)
T = percentage of catchment covered with forest
R = Percentage of catchment on sedimentary rock
P = annual average rainfall (mm).

By applying this function to the Loddon catchment in Northern Victoria, Greig and Devonshire were able to show that the cost, through increased stream salinity, of additional forest clearing was likely to be about $88 per hectare, or a perpetual annuity of $4.40 per hectare. They suggested that these sums could be levied as clearing taxes—$88 per hectare at the time of clearing or $4.40 per hectare annually in perpetuity from the time of clearing onwards. Hodge (1982) has suggested that one of the schemes for combating dryland salinity in Australia could involve government imposition of transferable quotas on the extent to which individuals are permitted to clear their land.

In a farm level study, we have taken a simulation modelling approach to the economic evaluation of dryland salinity control in Northern Victoria. The simulation model operates on a daily basis and incorporates relationships between site-specific characteristics (such as soil type, topography and weather) and annual crop and pasture yields from farming systems employing various rotations and tillage practices.

The amount of daily deep percolation of water beyond the rootzone was taken as a surrogate measure of the salinity-inducing characteristics of different farming systems through their influence on the phenomenon

TABLE 2
THE W. A. MURRAY CATCHMENT STUDY

	Existing Land Use	Allow Mining	Construct One Dam[a]	Allow Agroforestry
Land Assignment (ha × 10^3)				
National Parks	0	42	25	25
Forests	320	258	536	205
Agriculture	343	343	12	5
Mining/Forest	0	0	12	6
Mining/Agriculture	0	20	8	14
Agroforestry	0	0	0	338
Flora and Fauna Reserves	0	0	65	65
Net Present Value ($ × 10^6)				
Total NPV (7%)	100	435	359	446
River Flow ($m^3 \times 10^6$)	312	328	177	177
Salinity (ppm NaCl)	1 226	1 230	452	457

(Adapted from Bennett and Thomas 1983, Tables IV-6, IV-8, and IV-13).
[a] Salinity constrained to 500 ppm TDS.

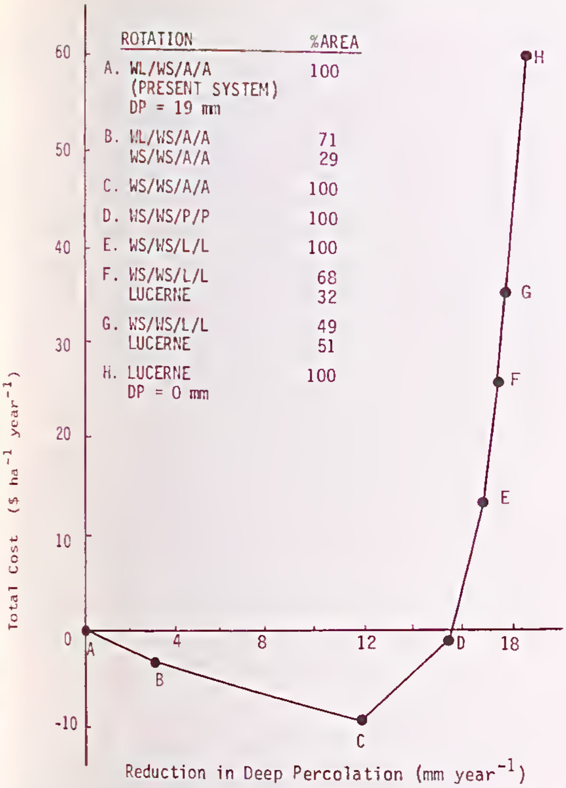

Fig. 1 – Total costs of reducing deep percolation – Kamarooka.

of groundwater recharge. The model was run for approximately 40 years using data for Kamarooka (wheat-sheep systems) and Axe Creek (grazing systems) in Northern Victoria.

The results from the simulation model were averaged and passed to a linear programming model to select "best" farming systems given relative commodity prices and variable production costs. Farming systems commonly practised in the two areas were then selected as the *base* systems against which alternative systems showing reduced deep percolation of water were compared. These analyses provided information on the important relationship between farm income and reduction in deep percolation. The results of the analyses are summarised in Fig. 1 for Kamarooka and Fig. 2 for Axe Creek.

In Fig. 1, WL is wheat, long fallow; WS is wheat, short fallow; A is annual pasture; P is perennial pasture; and L is lucerne. For Kamarooka, the current farming systems are estimated to result in average annual deep percolation of 19 mm. This figure can be reduced by about 12 mm per annum while *increasing* income, by substituting short fallow for long fallow in the rotation (system C). However, further reduction in deep percolation implies rapidly increasing costs to the operator.

The suggestion that farmers are currently opting for a farming system that is sub-optimal in terms of their net income warrants closer examination. The authors believe that they have made realistic assumptions concerning price relationships and input-output coefficients. However, the results are yet to be extensively tested under field conditions. Technical difficulties in establishing and managing the suggested farming systems may need to be overcome before widespread adoption can be expected.

It can be shown using marginal cost analysis that, while the equivalent of a tax or subsidy of about \$2.30 per mm deep percolation per annum would be required to persuade the operator to move from system C to system D (giving 84% reduction in deep percolation from base levels), it would be necessary to issue a tax or subsidy of about \$28.50 per mm per annum to move to system H involving all lucerne and no deep percolation.

For Axe Creek, current farming systems are estimated to result in average annual deep percolation of 34 mm. Any reduction from this figure would involve increasing costs to the operator. However, the increases are not as rapid as those for Kamarooka. The equivalent of a tax or subsidy of about \$0.20 per mm per annum should persuade the operator to move from system A (annual pastures) to system C which employs perennial pastures on 70% of the property and lucerne on the remaining 30%. At this point, deep percolation is reduced by about 92% from base levels.

Physical or engineering measures for control of dryland salinity such as river flushing, surface and underground drainage, and groundwater pumping were not evaluated by the authors. Such measures may be useful in some dryland situations. However, as Jenkin & Morris (1983) have indicated, they are mainly applicable to control of salinity in irrigation systems.

Some feasible landuse activities such as agroforestry or reforestation were not included in the above analyses and are to be considered in later work. However, these activities imply major changes to farming systems in

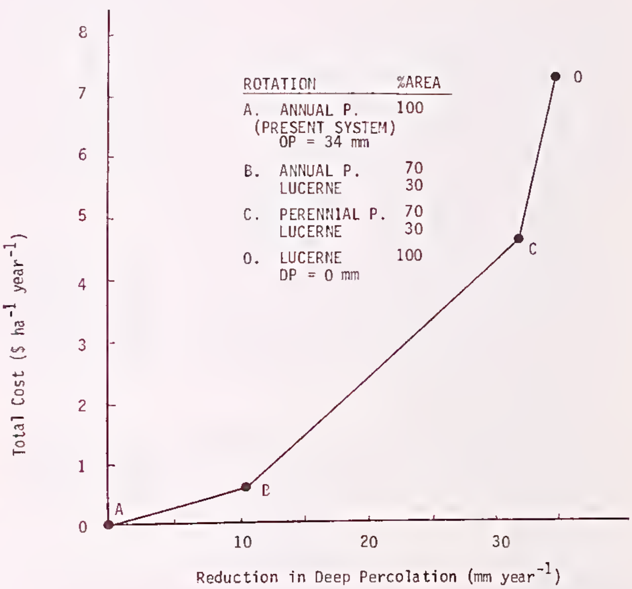

Fig. 2 – Total costs of reducing deep percolation – Axe Creek.

Northern Victoria and may not be any more profitable than the lucerne-based activities already examined. This does not necessarily mean that further clearing of existing forest or scrub is warranted on economic grounds. Indeed, the work of Greig & Devonshire (1981) described earlier indicates that any existing public incentives applied to clearing, such as business deductions or investment allowances for income taxation purposes, should probably be revoked.

SUMMARY AND CONCLUSIONS

It is clear that dryland salting is an important problem in Victoria, causing losses in agricultural production to the value of about $6 million per annum. To these losses must be added the costs of decreased water quality to Victorian and South Australian consumers.

Solutions to the problem are not so clear. Lack of knowledge concerning the physical processes involved; lack of concern for the off-site effects of land-use; and possible divergence between individual and community views of the importance of future costs and benefits all present obstacles to the rational use of land.

The paper compared several groups of policy options for controlling dryland salinity. It was suggested that the traditional research and extension roles of public agencies should continue to bring benefits to society by improving the availability of knowledge and increasing the rate at which improved technology is adopted by agricultural producers. In the simplest case, the causes and effects of dryland salinity are confined to land under the control of one individual or firm. In such cases it should be possible to persuade the landholder that his income will be improved by adopting technology aimed at controlling dryland salting.

Unfortunately, the causes of dryland salting are normally remote, in terms of time and place, from its effects. In such cases, fully informing the perpetrator of the actual or potential effects of his actions may not lead him to "mend his ways". Under such circumstances economists prefer the imposition of direct, per unit of pollution taxes on the perpetrator—a policy option which recognises the "polluter pays principle". This principle is difficult to apply in the case of dryland salinity, although it provides a useful basis for comparison with other policy options.

Subsidies for soil conservation works and land management practices have been the most common form of public intervention up until now. The subsidies are usually offered as part of voluntary programs which are often characterised by short-term success and long-term disappointment as farmers gradually lose interest for various reasons.

Direct controls on landuse also have potentially serious disadvantages in terms of unnecessarily draconian restrictions of landholders' managerial freedom and the arbitrary nature (in economic terms) of technical "standards" that may be established.

Despite the above difficulties, a review of some empirical economic studies suggests that there are some useful steps for public agencies to consider. Firstly, the agencies should closely examine any remaining incentives for clearing forest or scrub, such as are provided by income taxation allowances. (Some of these incentives are probably hang-overs from a past in which increases in agricultural exports were seen as the main avenue for improving the "balance of payments".) Secondly, quotas or taxes on further clearing could be considered. Finally, there appears to be scope for significantly alleviating the problem of dryland salinity through relatively minor changes in existing farming systems, involving modification of fallowing practices and introduction of deeper-rooted perennial grasses and legumes. More drastic approaches such as reforestation or agroforestry may only be required in limited areas.

ACKNOWLEDGEMENTS

The work reported here was partly supported by grants from the Soil Conservation Authority, Victoria and the Australian Water Resources Council. Thanks are due to G. W. Edwards, La Trobe University, W. A. Papst, Soil Conservation Authority, Victoria, and an anonymous referee for comments on a draft version of the paper. An earlier version of the paper was presented at a symposium on Salinity in Victoria (Dumsday 1983).

REFERENCES

Amihud, Y., 1976. The efficiency of taxes and subsidies in reducing emission by a risk-averse firm. *Kyklos*. 29: 113-117.

Anderson, F. R., Kneese, A. V., Reed, P. D., Taylor, S., & Stevenson, R. B., 1978. *Environmental improvement through economic incentives*. Johns Hopkins, Baltimore, 195 pp.

Baumol, W. J. & Oates, W. E., 1975. *The theory of environmental policy*. Prentice-Hall, New Jersey, Chapter 12, 172-190.

Bennett, D. & Thomas, J. F., eds, 1982. *On rational grounds: systems analysis in catchment land use planning*. Elsevier, New York, 362 pp.

Cary, J. W., Ferguson, J. O., & Belin, P., 1983. Economic and social costs of salinity. In *Salinity in Victoria*, M. J. Taylor *et al.* eds, Aust. Institute Agric. Sci., Melbourne, Occasional Pub. No. 6, 16-34.

Clark, S. D., 1979. *Groundwater law and administration in Australia*. Aust. Water Resources Council, Technical Paper No. 44, 379 pp.

Comptroller General of the United States, 1977. *To protect tomorrow's food supply, soil conservation needs priority attention*. Report to the Congress by the Comptroller General of the U.S., a G.A.O. Report, Washington, 59 pp.

Department of Environment, Housing and Community Development, 1978. *A basis for soil conservation policy in Australia*. Aust. Govt. Publishing Service, Canberra, Commonwealth and State Government Collaborative Soil Conservation Study 1975-77, Report 1, 193 pp.

Dumsday, R. G., 1983. Policy options for salinity management. In *Salinity in Victoria*, M. J. Taylor *et al.*, eds, Aust. Institute Agric. Sci., Melbourne, Occasional Pub. No. 6, 69-86.

Greig, P. J. & Devonshire, P. G., 1981. Tree removals and saline seepage in Victorian catchments: some

hydrologic and economic results. *Aust. J. Agric. Econ.* 25: 134-148.

GRIFFIN, R. C. & BROMLEY, D. W., 1982. Agricultural runoff as a nonpoint externality: a theoretical development. *Amer. J. Agric. Econ.* 64: 547-552.

HODGE, I., 1982. Rights to cleared land and the control of dryland-seepage salinity. *Aust. J. Agric. Econ.* 26: 185-201.

JENKIN, J. J. & MORRIS, J. D., 1983. Salinity problems outside the irrigation areas. In *Salinity in Victoria*, M. J. Taylor *et al.*, eds, Aust. Institute Agric. Sci., Melbourne, Occasional Pub. No. 6, 55-68.

MITCHELL, A., ZALLAR, S., JENKIN, J. J., & GIBBONS, F. R., 1978. *Dryland salting in Victoria, Australia*. Soil Conservation Authority, Victoria, 12 pp.

MOFFITT, L. J., ZILBERMAN, D., & JUST, R. E., 1978. A "putty-clay" approach to aggregation of production/pollution possibilities: an application in dairy waste control. *Amer. J. Agric. Econ.* 60: 452-459.

PECK, A. J., 1978. Salinization of non-irrigated soils and associated streams: a review. *Aust. J. Soil Research.* 16: 157-168.

SCHULTZ, T. W., 1982. *The dynamics of soil erosion in the United States: a critical view.* University of Chicago, Agricultural Economics Paper No. 82: 8, 22 pp.

SEITZ, W. D., 1981. A conservation tariff. *J. Soil and Water Conservation.* 36: 120-121.

SENECA, J. J. & TAUSSIG, M. K., 1979. *Environmental economics.* Prentice-Hall, New Jersey, 2nd Edition, 379 pp.

TAYLOR, M. J., DUMSDAY, R. G., & BRUYN, P. A., eds, 1983. *Salinity in Victoria.* Aust. Institute Agric. Sci., Melbourne, Occasional Pub. No. 6, 93 pp.

WILLIAMS, C. L., 1979. Soil conservation and water pollution control: the muddy record of the United States Department of Agriculture. *Boston College Environmental Affairs. Law Review* 7: 365-421.